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ORIGINAL ARTICLE

Route of gastroenteric reconstruction in pancreatoduodenectomy and delayed gastric emptying

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Abstract

Background: Delayed gastric emptying (DGE) is a frequent complication after pancreatoduodenectomy. Some previous studies suggest that antecolic (compared with retrocolic) gastroenteric reconstruction lowers the incidence of DGE. The present study was performed to investigate the relation between the route of gastroenteric reconstruction and DGE after pancreatoduodenectomy.

Methods: In a consecutive series of pancreatoduodenectomies, the route of gastroenteric reconstruction was retrospectively determined. Hospital course was prospectively recorded. Patients with antecolic and retrocolic reconstruction were compared. Primary outcome was DGE (ISGPS definition). Secondary outcomes were other complications and hospital stay.

Results: Of 154 included patients, 50% had retrocolic reconstruction. DGE occurred in 58% of retrocolic patients, vs 52% of antecolic patients (NS). 'Primary' DGE (without other intra-abdominal complications) occurred in 36% (retrocolic) and 20% (antecolic) ($P = 0.02$) of the patients. In multivariable analysis, the route of reconstruction was not associated with primary DGE. *Clinically relevant* primary DGE (grade B/C) did not differ, nor did the secondary outcomes.

Discussion: The incidence of DGE did not differ between the study groups. 'Primary' DGE was more frequent in the retrocolic group, but in multivariable analysis, no association between the route of reconstruction and primary DGE was found. The preferred route for gastroenteric reconstruction after pancreatoduodenectomy remains to be investigated in a well-powered, randomized, controlled trial.

Keywords

pancreatoduodenectomy, delayed gastric emptying, gastroenteric reconstruction, complication

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Introduction

In patients with a periampullary tumour, a pancreatoduodenectomy (PD) offers the only chance for a cure and therefore is the procedure of choice.[1] In recent years, mortality of the procedure has dropped to well below 5% in high volume centres, but morbidity remains high. Although not lethal, one of the most bothersome complications is delayed gastric emptying (DGE) which can prolong the hospital stay tremendously.[2,3]

DGE after PD was first described by Warshaw and Torchiana in the 1980s.[4] DGE implicates a state of gastroparesis, for which prolonged gastric drainage is necessary and delays the return to solid food intake. Throughout the years, many different definitions of DGE have been used, of which those by Yeo *et al.*[5] and Van Berge Henegouwen *et al.*[2] were among the two most widely recognized for a long time.[2,5] However, the persistent diversity of DGE definitions used made it difficult to compare results between different studies or centres. Hence, the International Study Group of Pancreatic Surgery (ISPGS) came up with a consensus definition of DGE in 2007.[3] Like most previous definitions, it is based on two clinical parameters: the necessity of prolonged nasogastric intubation and a delayed return to solid food tolerance. The definition also provides a grading system, based on the clinical impact of the gastroparesis (Table 1).[3]

The exact aetiology of DGE is still unknown. Proposed mechanisms include the absence of motilin stimulation after duodenal

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Table 1 Consensus definition of delayed gastric emptying according to the International Study Group of Pancreatic Surgery

DGE grade	NGT required	Unable to tolerate solid oral intake by POD
A	4–7 days or reinsertion > POD 3	7
B	8–14 days or reinsertion > POD 7	14
C	>14 days or reinsertion > POD 14	21

DGE, delayed gastric emptying; NGT, nasogastric tube; POD, post-operative day.

resection, pyloric or antral ischaemia and denervation of the stomach and duodenum.[6] Furthermore, the condition has been related to other intra-abdominal complications.[2] Some previous studies suggest a role for the route of gastroenteric reconstruction after PD in preventing DGE. This reconstruction can be created using an antecolic or retrocolic route. Both methods are widely accepted and commonly used according to the surgeons' preference. Two studies in particular (a non-randomized, retrospective study from Germany comparing two cohorts from different time periods and different hospitals, and a small randomized study from Japan) both suggest that an antecolic reconstruction leads to a lower incidence of DGE.[7,8] Possible explanations for their findings are that an antecolic gastroenteric anastomosis is less prone to torsion or angulation, and that it is located further away from the pancreaticojejunostomy and hepaticojejunostomy.

In the Academic Medical Center, the gastroenteric reconstruction used to be routed retrocolically, although in a slightly different manner compared with the above-mentioned studies: the duodenal stump (or distal stomach) is brought down through and affixed to a separate opening in the transverse mesocolon, which ensures that the gastroenteric anastomosis is not positioned in the same abdominal compartment as the hepaticojejunostomy and pancreaticojejunostomy.

Since the studies by Hartel *et al.* and Tani *et al.* were published,[7,8] an antecolic route has been used with increasing frequency, with the stomach positioned anteriorly to the transverse colon. However, these retrospective or small studies do not provide conclusive evidence about the preferred route of gastroenteric reconstruction; a point of view that has been expressed by several authors.[6,9] Furthermore, the increased use of an antecolic gastroenteric reconstruction seemed not to have led to a decreased incidence of clinically relevant DGE in the Academic Medical Center. The present study was performed to investigate the relation between the route of gastroenteric reconstruction and the incidence of DGE after PD.

Methods

Patients and study outline

In a consecutive series of PDs, performed from June 2005 to March 2009, the route of gastroenteric reconstruction was identified by reviewing operation reports. Clinicopathological data and peri-operative outcomes were prospectively recorded. As the present study involves a retrospective analysis of anonymized data, the regulations of the Dutch Ethical Review Board do not require informed consent.

Outcomes of patients with a retrocolic (n = 77, 50%) and antecolic (n = 77, 50%) gastroenteric reconstruction were compared. The primary outcome measure was the overall incidence of DGE according to the ISGPS definition.[3] The incidence of 'primary' DGE (DGE occurring in the absence of other intra-abdominal complications) was compared as well. Secondary outcome measures were other surgical complications, the need for (par)enteral nutritional support (as a result of any cause, including other complications and insufficient solid oral intake without DGE), hospital mortality and length of hospital stay. The other surgical complications included leakage of the pancreaticojejunostomy and haemorrhage (grade B or C according to the ISGPS definitions),[10,11] hepaticojejunostomy leakage, wound infection, intra-abdominal abscess and a rest category of 'other surgical complications'.

Surgical procedure

The standard surgical procedure was a pylorus-preserving PD. A classic Whipple's resection was only performed on indication of tumour ingrowth in the pylorus or proximal duodenum. In the case of limited tumour ingrowth in the portal or superior mesenteric vein, a segmental or wedge resection of the vessel was carried out.[12] Reconstruction was performed using end-to-side pancreaticojejunostomy, end-to-side hepaticojejunostomy and finally a duodeno- or gastrojejunostomy on the same jejunal limb, without Roux-en-Y reconstruction.

The retrocolic gastroenteric reconstruction was created as follows: the duodenal stump (or distal stomach) was brought down through a sufficiently wide, separate opening in the transverse mesocolon, at the left side of the middle colic artery and anastomozed to the jejunum with a running PDS 3-0 suture. The stomach was then affixed to the mesocolon to prevent herniation of the loop. This method ensures that the gastroenteric anastomosis is not positioned in the same abdominal compartment as the hepaticojejunostomy and pancreaticojejunostomy. In the antecolic reconstruction, the gastroenteric anastomosis was positioned anteriorly to the transverse colon, using the same suturing technique.

One silicone drain was left behind the hepatoduodenal ligament near the hepaticojejunostomy and pancreaticojejunostomy. Octreotide prophylaxis was only administered in patients with a soft pancreas or a non-dilated pancreatic duct. A prophylactic feeding jejunostomy was only performed on indication of severe weight loss or malnutrition. In the case of insufficient oral intake (owing to any cause, including DGE, other complications and insufficient solid oral intake in the absence of DGE), nutritional support was provided by placement of a nasojejunal feeding tube (preferably) or via total parenteral nutrition.

Statistical analysis

Results are presented as mean ± standard deviation (SD) or median with an interquartile range (IQR), depending on the distribution of the data. Continuous variables were compared between the study groups with the independent samples *t*-test (for normally distributed data) or Mann–Whitney *U*-test (for abnormally distributed data). Categorical data were compared with the chi-square test. Since the study design allows for dissimilarities in baseline or operation characteristics between the two study groups to occur, we decided to test eventual differences in outcomes in multivariable logistic regression analysis, with adjustment for such eventual dissimilarities.

P-values below 0.05 were considered to indicate statistically significant effects. All analyses were performed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA).

Results

Patient and operation characteristics

A flowchart of the study population is presented in Fig. 1. In the study period, 203 consecutive patients underwent a PD. In 47 (23%) patients, it was not possible to reliably establish the route of gastroenteric reconstruction, based on the operation report. These patients were excluded from further analysis, as well as two patients in whom a Roux-en-Y reconstruction was used. Patient characteristics of the antecolic and retrocolic groups are displayed in Table 2, whereas Table 3 summarizes the operation characteristics. There was a shift from mostly retrocolic reconstruction in the early years of the study period, to mostly antecolic reconstruction in the more recent years. This is clearly visualized in Fig. 2.

Primary and secondary outcomes

There incidence of overall and primary DGE, and their distribution in grades, are displayed in Table 4. The only difference that was found between the retrocolic and antecolic groups, namely the incidence of overall primary DGE, was tested in a multivariable logistic regression analysis, which was adjusted for the following dissimilarities in patient and operation characteristics of

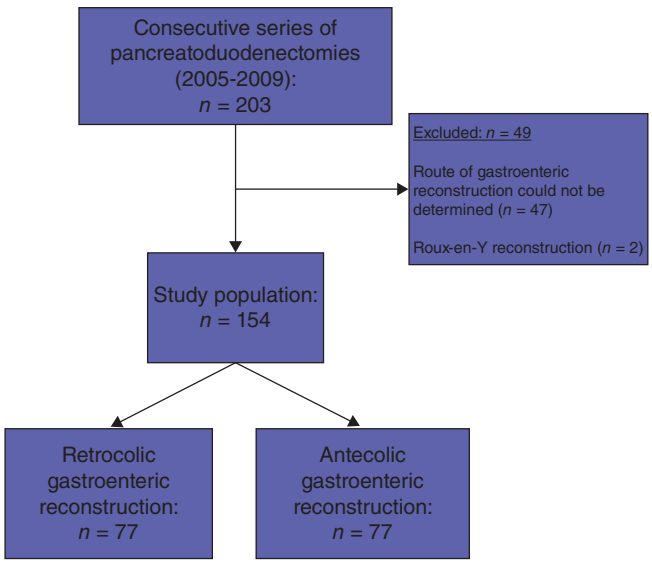

Figure 1 Flowchart of the study

Table 2 Baseline characteristics of patients undergoing PD with a retrocolic or antecolic gastroenteric reconstruction

	Retrocolic (*n* = 77)	Antecolic (*n* = 77)	*P*-value
Age in years – mean (SD)	64.3 (11.6)	64.0 (9.3)	0.851
Male gender – no. (%)	37 (48)	44 (57)	0.259
ASA classification – no. (%)			
I	7 (9)	18 (24)	0.030
II	50 (65)	46 (61)	
III / IV	20 (26)	12 (16)	
Comorbidity – no. (%)			
Cardiac	16 (21)	16 (21)	1.000
Pulmonary	10 (13)	9 (12)	0.783
Hypertension	21 (27)	15 (20)	0.253
Diabetes mellitus	11 (14)	12 (16)	0.795
Underlying disease – no. (%)			
Pancreatic adenocarcinoma	30 (39)	33 (43)	0.603
Ampullary adenocarcinoma	13 (17)	13 (17)	
Distal CBD adenocarcinoma	10 (13)	13 (17)	
Other (pre)malignant	12 (16)	9 (12)	
Chronic pancreatitis	8 (10)	3 (4)	
Other benign	4 (5)	6 (8)	

PD, pancreatoduodenectomy; SD, standard deviation; ASA, American Society of Anesthesiologists; CBD, common bile duct.

Table 3 Treatment characteristics of patients undergoing PD with a retrocolic or antecolic gastroenteric reconstruction

	Retrocolic (*n* = 77)	Antecolic (*n* = 77)	*P*-value
Duration of operation in min – mean (SD)	288 (76)	320 (107)	0.036
Pylorus preserved – no. (%)	75 (97)	68 (88)	0.029
Prophylactic octreotide – no. (%)	37 (48)	40 (52)	0.629
Year of operation – no. (%)			
2005	40 (52)	3 (4)	<0.001
2006	23 (30)	7 (9)	
2007	6 (8)	29 (38)	
2008	7 (9)	33 (43)	
2009	1 (1)	5 (7)	
Operated in first half of study period – no. (%)	67 (87)	15 (20)	<0.001

PD, pancreatoduodenectomy; SD, standard deviation.

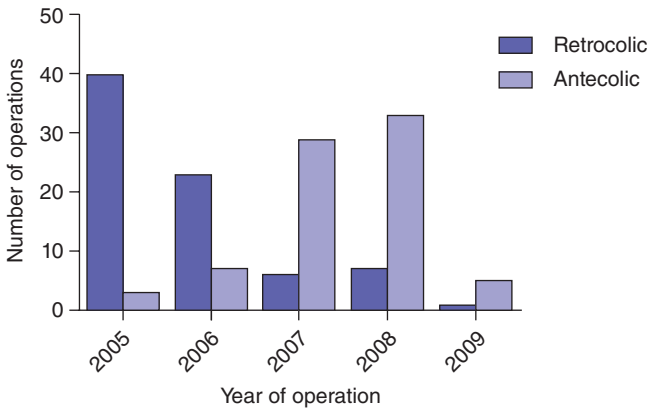

Figure 2 Bar chart displaying the number of included operations using antecolic and retrocolic reconstruction per year

Table 4 DGE and primary DGE after PD with retrocolic or antecolic gastroenteric reconstruction

	Retrocolic (*n* = 77)	Antecolic (*n* = 77)	*P*-value
DGE			
DGE of any grade – no. (%)	45 (58)	40 (52)	0.418
DGE, distribution in grades – no. (%)			
No DGE	32 (42)	37 (48)	0.873
DGE Grade A	19 (25)	16 (21)	
DGE Grade B	13 (17)	12 (16)	
DGE Grade C	13 (17)	12 (16)	
DGE Grade B or C – no. (%)	26 (34)	24 (31)	0.731
Primary DGE			
Primary DGE of any grade – no, (%)	28 (36)	15 (20)	0.020
Primary DGE, distribution in grades – no. (%)			
No primary DGE	49 (64)	62 (81)	0.125
Primary DGE Grade A	14 (18)	7 (9)	
Primary DGE Grade B	9 (12)	6 (8)	
Primary DGE Grade C	5 (7)	2 (3)	
Primary DGE Grade B or C	14 (18)	8 (10)	0.167

DGE, delayed gastric emptying; PD, pancreatoduodenectomy.

Table 5 Multivariable logistic regression analysis determining risk factors for primary DGE of any grade

	OR	(95% CI)
Retrocolic route of gastroenteric reconstruction[a]	1.79	(0.64–4.99)
ASA classification[b]		
Class II	1.01	(0.34–2.97)
Class III/IV	1.10	(0.32–3.81)
Preservation of the pylorus	0.65	(0.15–2.91)
Duration of operation – half hour increase	0.90	(0.78–1.03)
Operated upon in first half of study period[c]	1.36	(0.48–3.84)

[a]Reference category: antecolic gastroenteric reconstruction.
[b]Reference category: ASA class I.
[c]Reference category: operated upon in second half of study period.
PD, pancreatoduodenectomy; DGE, delayed gastric emptying; OR, odds ratio; CI, confidence interval; ASA, American Society of Anesthesiologists.

Table 6 Other outcomes after PD with retrocolic or antecolic gastroenteric reconstruction

	Retrocolic (*n* = 77)	Antecolic (*n* = 77)	*P*-value
Other surgical complications – no. (%)			
Pancreaticojejunostomy leakage	16 (21)	16 (21)	1.000
Hepaticojejunostomy leakage	1 (1)	4 (5)	0.173
Haemorrhage	2 (3)	6 (8)	0.146
Wound infection	12 (16)	9 (12)	0.501
Intra-abdominal abscess	2 (3)	1 (1)	0.560
Other	7 (9)	7 (9)	1.000
Need for (par)enteral nutritional support – no. (%)[a]	29 (38)	22 (29)	0.231
Hospital mortality – no. (%)	2 (3)	4 (5)	0.405
Length of hospital stay in days – median (IQR)	13 (16)	11 (8)	0.593

[a]Due to any cause (including DGE, other complications, and insufficient oral intake in the absence of DGE).
DGE, delayed gastric emptying; PD, pancreatoduodenectomy; IQR, interquartile range.

the two study groups: year of operation, American Society of Anesthesiologists (ASA) class, preservation of the pylorus and duration of operation (Table 5). In this multivariable analysis, the route of gastroenteric reconstruction was not associated with the occurrence of primary DGE – neither was any of the other included variables.

Finally, Table 6 displays the secondary outcome measures, which did not differ between the retrocolic and antecolic groups.

Discussion

Delayed gastric emptying is a frequent and bothersome complication after a PD. Some previous studies suggest that using an antecolic route for the gastroenteric reconstruction leads to a lower incidence of DGE, as compared with a retrocolic route,[7,8] but the evidence is limited.[6,9] Nevertheless, an antecolic gastroenteric reconstruction has been used more frequently in recent years in the Academic Medical Center. The present study was performed to investigate the association between the route of gastroenteric reconstruction after PD and the incidence of postoperative DGE.

There was no difference between the two groups in the incidence of DGE – neither in DGE of any grade according to the ISGPS definition, nor in clinically relevant DGE (grade B or C). In the retrocolic group, there was a higher incidence of primary DGE

(occurring in absence of other intra-abdominal complications). This difference was not found when the analysis was adjusted for dissimilarities in baseline and operation characteristics. There were no differences in clinically relevant primary DGE, the need for nutritional support or other complications.

Although this is a non-randomized study as well, these results suggest that there is no association between the route of gastroenteric reconstruction and the incidence of DGE, contrary to the findings by Hartel *et al.* and Tani *et al.* The higher incidence of primary DGE in the retrocolic group was not proven in multivariable analysis, which was adjusted for ASA class, pylorus preservation, duration of operation and year of operation. This difference in primary DGE was largely caused by a higher incidence of grade A DGE in the retrocolic group. Grade A DGE is already present when the nasogastric intubation lasts longer than 3 post-operative days, and has generally no impact on the clinical course. It may well be that the higher incidence of grade A DGE in the retrocolic group, with mostly patients from the early years of the study period, reflects a gradual change in post-operative management. With the emergence of enhanced recovery programmes in other types of surgery and the recognition of the harmful effects of unnecessary prolonged nasogastric intubation, such as the induction of pulmonary complications,[13,14] there may have been a general tendency in more recent years towards earlier removal of the nasogastric tube in patients with an uncomplicated post-operative course. This reflects the more 'Fast Track' type recovery schemes at the wards in the Academic Medical Center.

The difference of the present results with the findings of earlier studies comparing antecolic with retrocolic gastroenteric reconstruction,[7,8] may be a consequence of the technique that is used in the Academic Medical Center for the creation of a retrocolic gastroenteric reconstruction. By bringing the duodenal stump or distal stomach down through the transverse mesocolon and suturing it to the mesocolon, the gastroenteric anastomosis is situated in another compartment than the hepaticojejunostomy and pancreaticojejunostomy. Local inflammation around these anastomoses is therefore less likely to affect the gastroenteric anastomosis.[15] Remarkably enough, Hartel *et al.* used exactly this theory to explain the lower DGE incidence after antecolic reconstruction: in the antecolic reconstruction, the gastroenteric anastomosis was located further away from the pancreaticojejunostomy than in the retrocolic reconstruction according to their technique.[7]

Another theory that has been used to explain lower DGE incidences after antecolic reconstruction is more mechanical: a retrocolic reconstruction is believed to be more prone to torsion or angulation, causing DGE by mechanical obstruction.[7,16] Probably, by suturing the duodenal stump or distal stomach to the mesocolon, the risk of torsion or angulation is minimized.

The present study is limited by the retrospective identification of the route of the gastroenteric reconstruction. Unfortunately in a substantial amount of patients, the operation report did not mention this route. One could speculate that this would be more often the case in the patients with a retrocolic reconstruction, as this used to be the standard procedure. However, the large number of included operations performed in 2005 (in which the retrocolic route was predominantly used) shows that this is not likely. In fact, the constant number of included operations per year gives us no reason to assume a large difference in the amount of antecolic and retrocolic anastomoses in the excluded patients. Another limitation is the non-randomized design of the study. Selection bias cannot be ruled out. This objection was met by the use of multivariable logistic regression, adjusted for the dissimilarities in baseline and treatment characteristics that had occurred as a result of this non-randomized design.

In spite of these shortcomings, the present study describes a large series of patients undergoing PD, with their hospital course prospectively recorded. The study uses a commonly accepted definition of DGE, according to the ISGPS criteria.[3] The results provide findings which are in contrast with earlier studies on the route of gastroenteric reconstruction after PD. However, the present results are in line with a recently published randomized trial from India, in which Gangavatiker and co-workers found no relation between the route of gastroenteric reconstruction and the incidence of DGE.[17] However, this previous study also has its shortcomings: it is again a relatively small series, from just one centre. Patients who had diabetes, pre-operative gastric outlet obstruction or who were older than 70 years were excluded and the proportion of patients undergoing a 'classic' Whipple's resection was high (65%), in comparison with current Western series. Finally, analysis was not performed by intention to treat (deceased patients were excluded from further analysis) and DGE was diagnosed by means of the old John Hopkins criteria[5]; the ISGPS criteria were retrospectively applied, but only to the patients who had DGE according to the John Hopkins criteria.[17]

In conclusion, the results of the present study suggest that there is no association between the route of gastroenteric reconstruction in PD and DGE. Bearing in mind that previous literature on this subject is either retrospective or underpowered, or not flawlessly designed, it may well be that the only way to decide the debate which, if any, route of gastroenteric reconstruction is preferable in pancreatoduodenectomy, is by conducting a well-powered, randomized, controlled, multicentre trial.

Conflicts of interest

None declared.

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